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ANTHROPOMETRIC DATA FOR PELVIC GEOMETRY DEFINITION

By

Clyde C. Snow
Herbert M. Reynolds

During the Third Annual Workshop on Human Subjects for Biomechanical Research, reports by Thomas, et al (1), Reynolds (2), and Padgaonkar, et al (3) presented thoughts and recommendations regarding the definition of a coordinate system for use in locating the position of the human pelvis in three-dimensional space. Such a coordinate system is necessary in biomechanical research to consistently define the dynamic response of the pelvis to impact. It also serves as an essential starting point in relating the results of experiments to the human population of concern. However, before such a relationship can be made, it is necessary to be able to describe the population characteristics in equivalent terms. To date, there has been no systematic three-dimensional measurement of the human pelvis in statistically significant numbers to describe the population. The task which will be described is intended to provide a geometric, spatial analysis of the normal human pelvis to enable definition of small, medium and large body sizes of both sexes in the U.S. population.

Research on a sample of osteological specimens has begun at the Civil Aeromedical Institute in Oklahoma City. This research is being sponsored by the FAA (AM-B-77-PRS-60), NHTSA (DOT-HS-6-01356) and AFOSR (F-44620-76-C-0015). Specimens for this study are obtained on load from the Hamann-Todd Collection in the Cleveland Museum of Natural History. This collection consists of nearly 3,000 human skeletons of documented age, sex, race, and cause of death obtained from dissection cadavers at the Western Reserve School of Medicine Complete anthropometrics were recorded on each body prior to

skeletonization.

The Hamann-Todd collection does not represent a random sampling of the U.S. population in regard to age, sex, and racial composition, since, as in many dissecting-room series, Negroes, males, and the elderly are over-represented. However, the collection is large enough to allow the selection of a stratified subsample matching the present U.S. population in its age, sex, and racial characteristics.

The subsampling procedure to be used in this study was accomplished by a computer program at the University of Michigan Highway Safety Research Institute. This program, treating the sexes separately, selected individuals from the collection who, in terms of stature and weight, represent three body sizes:

> Small: Individuals who fall below the 25 percentile limits of a height/weight bivariate of the general U.S. population.
>
> Medium: Individuals who fall between the 25th and 75th percentile limits of a height/weight bivariate of the general U.S. population.
>
> Large: Individuals who fall above the 75th percentile limits of a height/weight bivariate of the general U.S. population.

This sampling scheme is diagrammed in Figure 1. The computer then selects, from each of the above "size cells," a sample (N=25) matching as closely as possible the present U.S. population in racial composition and age profile. The specimens will consist of twelve subsample sets of N-300. The key biometric variables of the subsample sets are shown in Figure 1. This sampling strategy has provided us with subsamples reasonably comparable to corresponding population groups, which are valuable from the standpoint of human bio-engineering applications since extremes of body size are well represented.

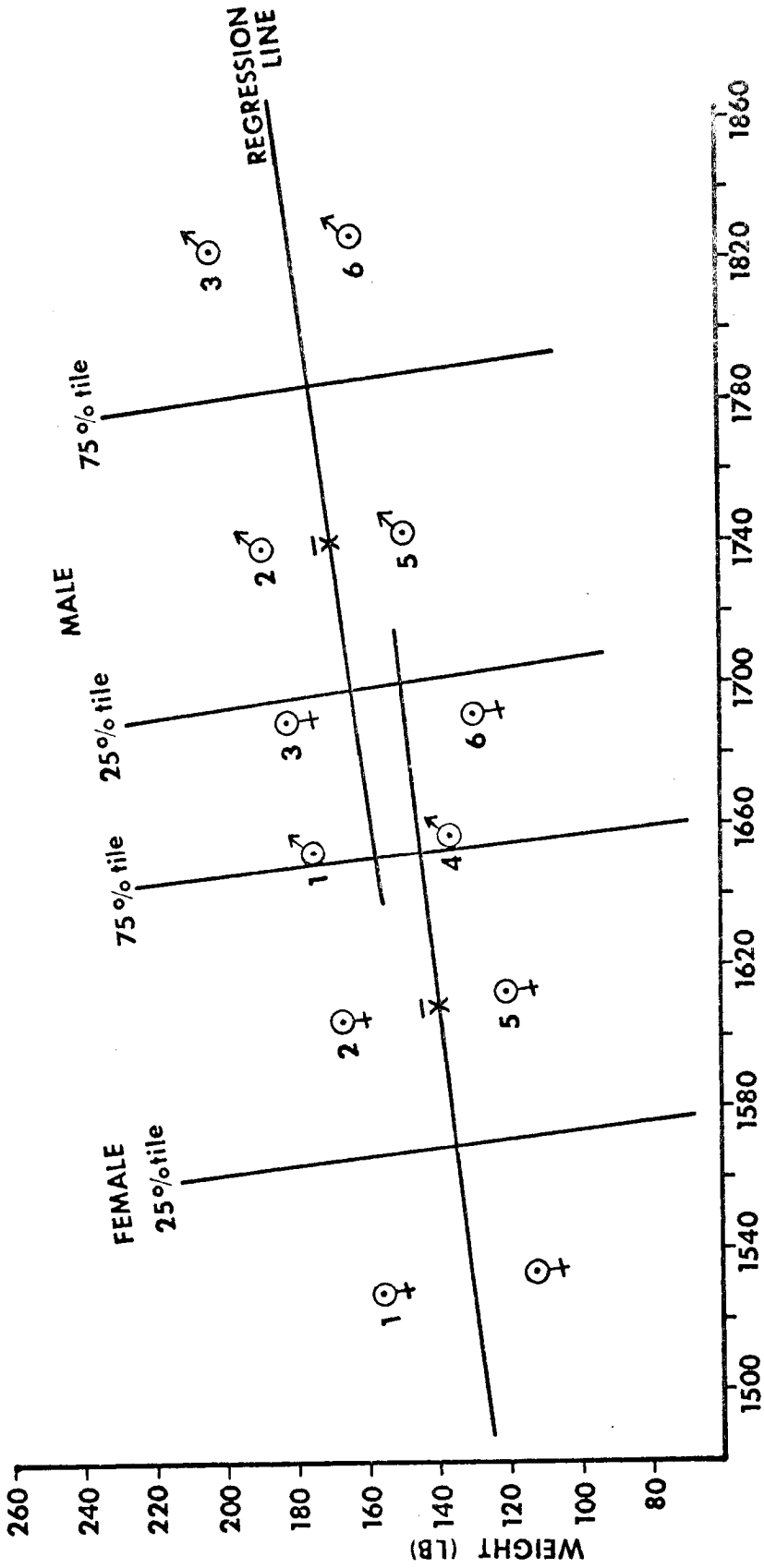


Figure 1 Sampling Scheme for Male and Female Specimens from the Hamann - Todd Skeletal Collection.

Rosters identifying the specimens to be used in this study have been furnished to the Curator of the Hamann-Todd Collection. Arrangements have been made to send the selected specimens in shipments of 30 males and 30 females at a time to the Physical Anthropology Research Unit at the Civil Aeromedical Institute (CAMI).

Once received, the specimens have to be processed for measuring. An initial step will be degreasing of the bones (sacrum, both ilia and left femur). Following degreasing, the necessary landmarks will be applied to the specimens and the bones will be photographed in three orthogonal views. The landmarks are depicted in Figures 2 through 14.

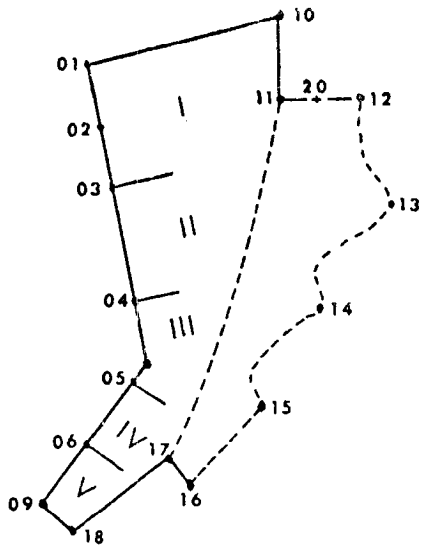
The equipment that will be used to register landmarks on the specimens consists of a Hewlett-Packard Model 9864A digitizer with input into a Hewlett-Packard Model 9820A calculator. This system has been modified by attaching a diagraph to the digitizing curser of the plotting board so that the point of the diagraph needle is directly vertical to the cross-hairs of the digitizer at all times. A potentiometer on the diagraph registers the height of the needle above the plotting board and provides Z-axis data to the computer. The specimen is suspended over the board in a position allowing access to all of the landmarks on the bone. The diagraph is maneuvered so that the needle is in contact with a given landmark. A single signal, activated on the digitizer, registers the X, Y, Z coordinates of the landmark in relation to an origin on the board. The spatial location of each registered landmark can then be transformed in reference to an anatomical axis system which is based on a transverse plane formed by the midpoint of the antero-superior margin of the sacrum (promontorion) and the left and right anterior-superior iliac spines.

Except for a few reference marks on the right hemipelvis, most of the landmarks will be recorded on the left hemi-

pelvis only. Assuming bilateral symmetry, the projection of left-registered points to the right can be accomplished by a computer program under current development.

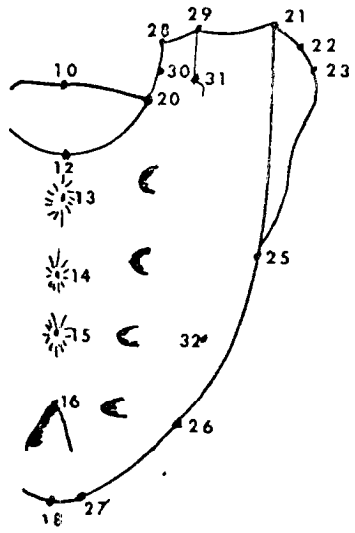
Repeated calibration runs on test specimens reveal a mean accuracy of $\pm$ 0.5 mm on computed point-to-point linear measurements. Such accuracy exceeds that obtained by ordinary osteological techniques.

In conclusion, these data will provide an estimate of the variation in pelvic geometry within the adult male and female civilian population. The definition of axes systems using anatomical landmarks needs relatively "stable", palpable landmarks that are commensurately distant. This information can be obtained in a reasonably large sample representative of extreme body sizes in the general U.S. civilian population. Additional uses of these data will include specification of representative pelves for different size anthropometric dummies, identification and description of remains in forensic cases, and quantitative information on the shape and size variability of the human pelvis.



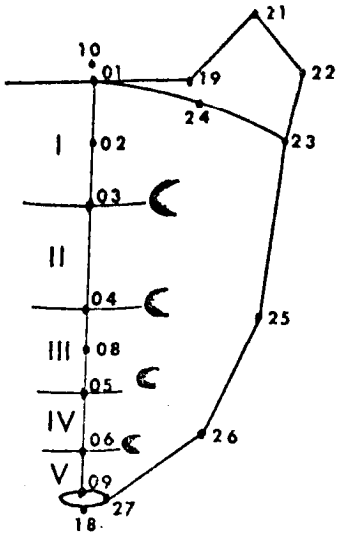
01	Promontorion
02	S1 Center
03-07	Segment Union Points
09	Caudion, Anterior
10	1st Sacral Body, Posterior
11	Sacral Canal, Supero-anterior Floor
12	Sacral Canal, Anterior Roof
13	Sacral Spine, S1
14	Sacral Spine, S2
15	Sacral Spine, S3
16	Sacral Canal, Posterior Roof
17	Sacral Canal, Infero-anterior Floor
18	Caudion, Posterior
19	Sacral Canal, Wall

Figure 2 Sagittal view of Sacrum showing midline landmarks.



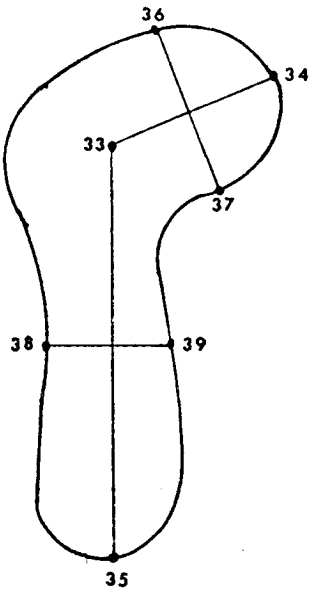
10	1st Sacral Body, Posterior
12	Sacral Canal, Anterior Roof
13	Sacral Spine, S1
14	Sacral Spine, S2
15	Sacral Spine, S3
16	Sacral Canal, Posterior Roof
18	Caudion, Posterior
20	Sacral Canal, Wall
21	Posterior Alar-Auricular Point
22	Lateral Alar-Auricular Point
23	Anterior Alar-Auricular Point
25	Inferior Sacro-Iliac Junction
26	Inferior Sacral Angle
27	Caudion, Lateral
28-31	Superior Auricular Facet
32	Posterior Sacral Tubercle

Figure 3 Posterior view of Sacrum showing midline and lateral landmarks.



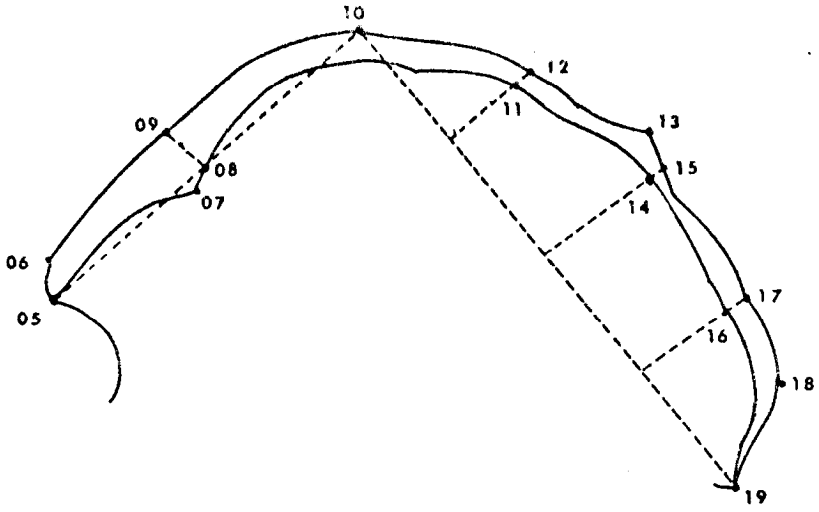
01	Promontorion
02	S1 Center
03-07	Segment Union Points
09	Caudion, Anterior
10	1st Sacral Body, Posterior
18	Caudion, Posterior
19	1st Sacral Body, Lateral
21	Posterior Alar-Auricular Point
22	Lateral Alar-Auricular Point
23	Anterior Alar-Auricular Point
24	Mid-Alar-Auricular Point
25	Inferior Sacro-Iliac Junction
26	Inferior Sacral Angle
27	Caudion, Lateral

Figure 4 Anterior view of Sacrum showing midline and lateral lanmark



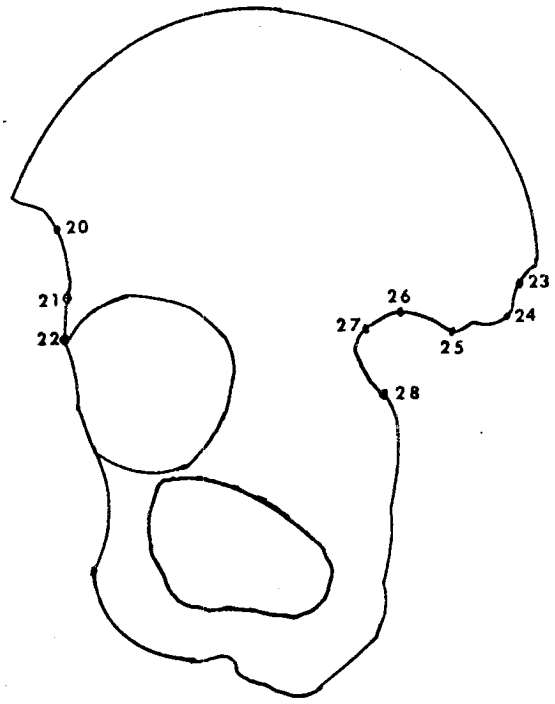
33	Sacro-Iliac Midpoint
34	Superior Pole
35	Inferior Pole
36	Superior Lobe, Superior Margin Midpoint
37	Superior Lobe, Inferior Margin Midpoint
38	Inferior Lobe, Anterior Margin
39	Inferior Lobe, Posterior Margin

Figure 5 Lateral view of Sacro-Iliac joint surface showing landmarks.



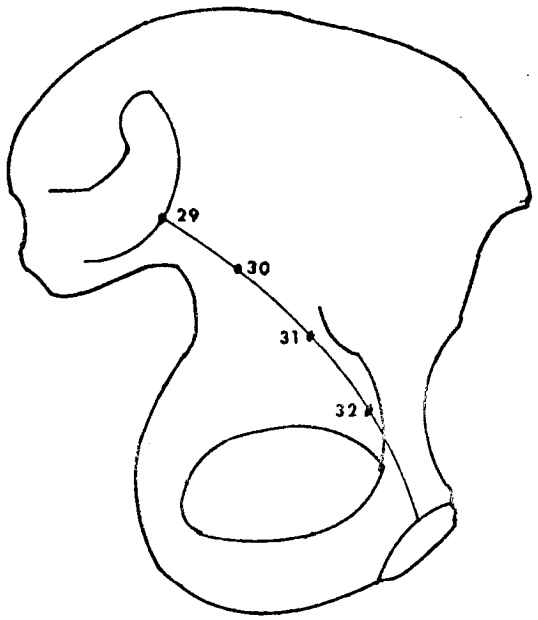
05 Iliospinale, Antero-superior
06 Iliospinale, Crest
07 Iliocristale, Antero-lateral
08 Anterior Segment Midpoint, Lateral
09 Anterior Segment Midpoint, Medial
10 Iliocristale, Summum
11 Posterior Segment Point, Anterior Lateral (1st)
12 Posterior Segment POint, Anterior Medial (1st)
13 Iliocristale, Postero-medial
14 Posterior Segment Point, Intermediate Lateral (2nd)
15 Posterior Segment Point, Intermediate Medial (2nd)
16 Posterior Segment Point, Posterior Lateral (3rd)
17 Posterior Segment Point, Posterior Medial (3rd)
18 Iliocristale, Posterior
19 Iliospinale, Postero-superior

Figure 6 Lateral view of Iliac Crest Showing Landmarks.



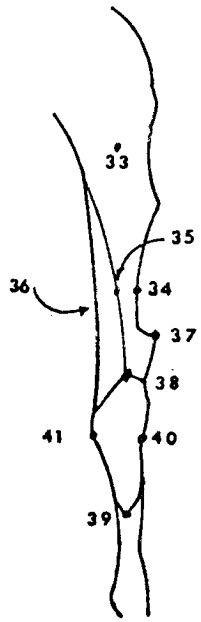
20 Anterior Iliac Notch Point
21 Iliospinale, Antero-Inferior
22 Anterior Iliac Base Point
23 Posterior Iliac Notch Point
24 Iliospinale, Postero-inferior
25 Bouisson Tubercle
26 Superior Sciatic Notch Point
27 Apex of Sciatic Notch
28 Anterior Sciatic Notch Point

Figure 7 Lateral view of Innominate showing anterior and posterior Iliac border landmarks.



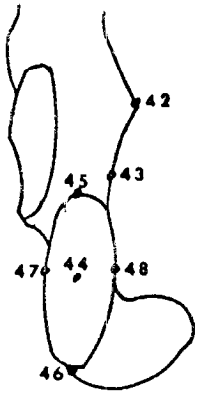
29 Anterior Auricular Point
30 Posterior Inlet Point
31 Intermediate Inlet Point
32 Anterior Inlet Point

Figure 8 Medial view of Innominate showing Pelvic Inlet landmarks.



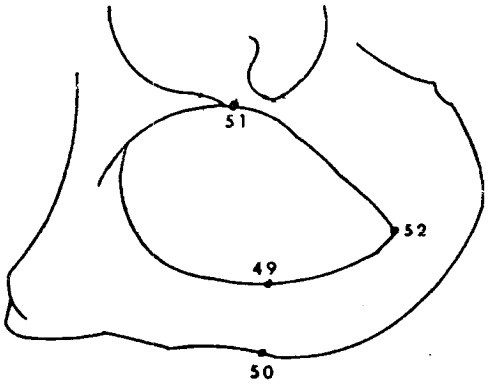
33 Pubic Eminence Point
34 Anterior Pubic Ramus Point
35 Superior Pubic Ramus Point
36 Inferior Pubic Ramus Point
37 Pubotubercle
38 Superior Symphyseal Pole
39 Inferior Symphyseal Pole
40 Anterior Symphyseal Point
41 Posterior Symphyseal Point

Figure 9 Medial view of Pubis showing landmarks.



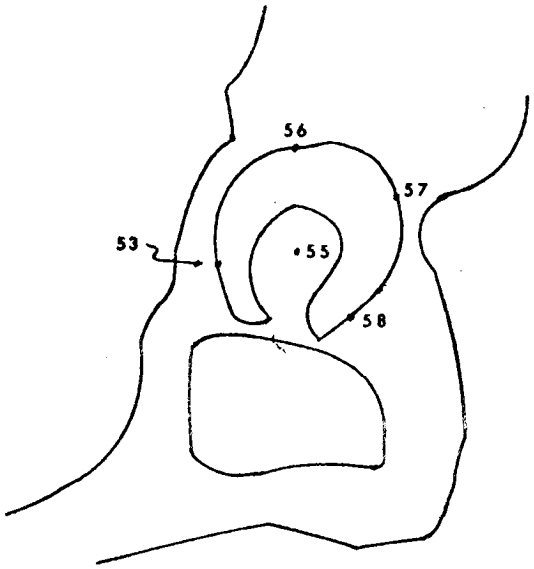
42 Ischio-spinale
43 Posterior Ischial Border Point
44 Ischiale
45 Superior Tuberosity Pole
46 Inferior Tuberosity Pole
47 Antero-lateral Tuberosity Pole
48 Postero-medial Tuberosity Pole

Figure 10 Posterior view of Ischium showing landmarks.



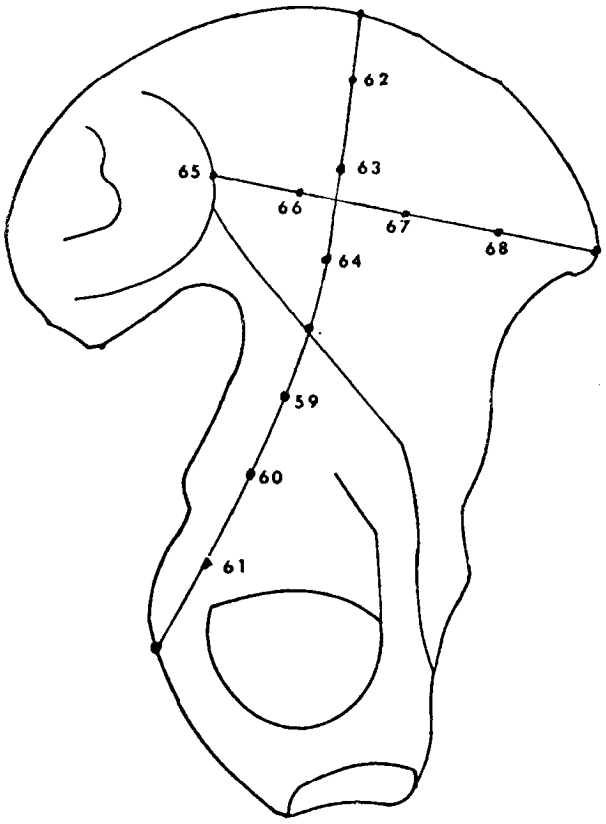
49 Superior Ischio-Pubic Ramus Point
50 Antero-inferior Ischio-Pubic Ramus Point
51 Obturator Tubercle Point
52 Inferior Obturator Foramen Point

Figure 11 Lateral view of Ischium and Pubis showing landmarks.



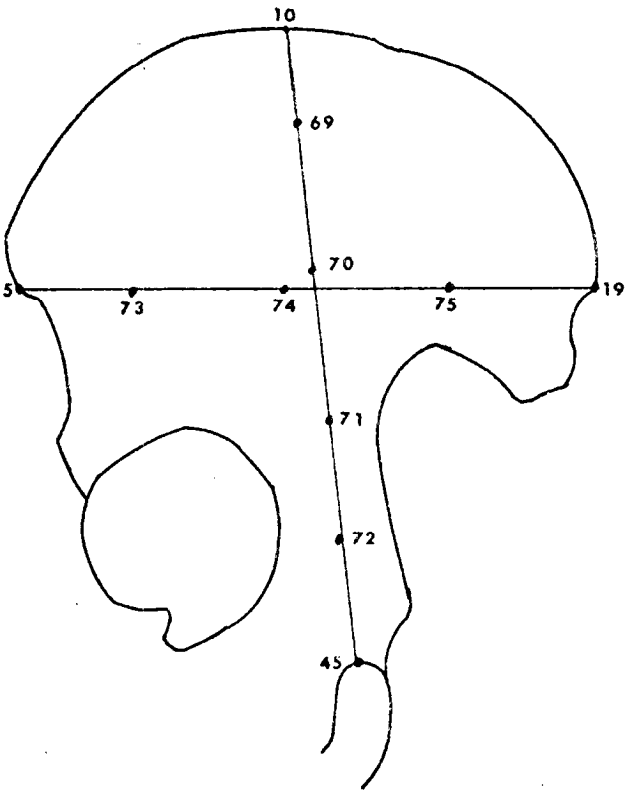
53 Acetabulum, Anterior
54 H-Point (Not shown)
55 Acetabular Center Point
56 Acetabulum, Superior
57 Acetabulum, Posterior
58 Acetabulum, Inferior

Figure 12 Lateral view of Acetabulum showing landmarks.



59 Superior Ischial Inner Surface Point
60 Intermediate Ischial Inner Surface Point
61 Inferior Ischial Inner Surface Point
62 Superior Vertical Iliac Fossa Contour Point
63 Intermediate Vertical Iliac Fossa Contour Point
64 Inferior Vertial Iliac Fossa Contour Point
65 Lateral Auricular Point
66 Posterior Transverse Iliac Fossa Contour Point
67 Intermediate Transvers Iliac Fossa Contour Point
68 Anterior Transverse Iliac Fossa Contour Point

Figure 13 Medial view of Innominate showing surface contour landmarks.



05 Segment Union POint
10 1st Sacral Body, Posterior
19 1st Sacral Body, Lateral
45 Superior Tuberosity Point
69 Superior-most Vertical Lateral Ischio-Iliac Contour Point
70 Superior-Intermediate Vertical Lateral Ischio-Iliac Contour Point
71 Inferior-Intermediate Vertical Lateral Ischio-Iliac Contour Point
72 Inferior-most Vertical Lateral Ischio-Iliac Contour Point
73 Anterior Transvers Lateral Iliac Surface Contour Point
74 Intermediate Transvers Lateral Iliac Surface Contour Point
75 Posterior Transvers Lateral Iliac Surface Contour Point

Figure 14 Lateral view of Innominate showing Surface Contour landmarks.

REFERENCES

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2. Reynolds, H.M.: Anthropometric Considerations for Biokinematic Research. Third Annual International Workshop on Human Subjects for Biomechanical Research, Committee Reports and Technical Discussions, San Diego, California, November 19, 1975, pp. 27-67.

3. Padgaonkar, A.J., et al.: A Pelvis Anatomical Coordinate System. Third Annual International Workshop on Human Subjects for Biomechanical Research, Committee Reports and Technical Discussions, San Diego, California, November 19, 1975, pp. 93-102.